

REMARKS

Claims 4-7 are pending in the present application. Claims 4-5 are herein amended.

Claims 13-14 and 17-18 are herein canceled. No new matter has been presented.

Rejections under 35 USC §102(a)

Claims 4-6, 13, 14 and 17-18 were rejected under 35 U.S.C. 102(a) as being clearly anticipated by Funahashi et al. (Funahashi, R., S. Urata, K. Mizuno, T. Kouuchi, and M. Mikami, “Ca_{2.7}Bi_{0.3}Co₄O₉/La_{0.9}Bi_{0.1}NiO₃ Thermoelectric Devices with High Output Power Density.” Applied Physics Letters 85.6 (2004): 1036-1038.).

Claims 13, 14 and 17-18 have been cancelled making the rejection of these claims moot.

Therefore, claims 4-6 are discussed below.

Funahashi et al. was published on August 9, 2004, which is later than the October 8, 2003, which is the filing date of Japanese Application No. 2003-348913, the priority of which is claimed in the present application.

Applicant hereby submits a verified English translation of Japanese Patent Application No. 2003-348913. Thus, this rejection is overcome and should be withdrawn.

More specifically, Funahashi et al. which was published on August 9, 2004, discloses a thermoelectric device connecting a p-type material represented by Ca_{2.7}Bi_{0.3}Co₄O₉ and an n-type material represented by La_{0.9}Bi_{0.1}NiO₃ and teaches that a thermoelectric unicouple is constructed using Ag paste containing p- and n-type oxide powders.

On the other hand, the present invention was filed on September 29, 2004 as a PCT International Application, claiming the priority of Japanese Patent Application No. 2003-348913

(filed on October 8, 2003). Applicant attaches an English translation of Japanese Patent Application No. 2003-34891. As is clear from the translation, Examples 1-3 and many other examples of Japanese Patent Application No. 2003-348913 indicate that thermoelectric conversion elements were produced by connecting a p-type thermoelectric material represented by $\text{Ca}_{2.7}\text{Bi}_{0.3}\text{Co}_4\text{O}_{9.2}$ to an electrically conductive substrate using a paste comprising a complex oxide represented by $\text{Ca}_{2.7}\text{Bi}_{0.3}\text{Co}_4\text{O}_{9.2}$, which is substantially identical to the oxide described in Funahashi et al.

Therefore, the invention relating to an electrically conductive paste for connecting a p-type thermoelectric material claims a valid priority, and is deemed to have been filed on October 8, 2003.

In contrast, as stated above, Funahashi et al. was published on August 9, 2004, which is later than the priority date of the present application; therefore, this reference does not support the rejection under 35 USC §102(a).

Consequently, the 35 U.S.C. 102(a) rejection of Claims 4-6 should be withdrawn.

Rejections under 35 USC §103(a)

Claims 4-7 were rejected under 35 U.S.C. 103(a) as being obvious over Xu et al. (Xu et al., "High Temperature Transport Properties of $\text{Ca}_{3-x}\text{Na}_x\text{Co}_4\text{O}_9$," Solid State Communications 124 (2002): 73-76.), in view of Alexander (U.S. Patent No. 5,422,190).

Claim 4 has been amended to clarify that a p-type thermoelectric material, which is the target for connection of an electrically conductive paste, is made of a complex oxide, and that the paste is used to connect the p-type thermoelectric material to an electrically conductive substrate.

In Claims 4 and 5, Na has been deleted from the options for A^1 in the oxide represented by the formula $Ca_aA^1_bCo_cA^2_dO_e$ to be mixed in the electrically conductive paste for connecting a p-type thermoelectric material. This amendment is intended to clarify the difference from the oxide described in Xu et al. Also, in Claims 4 and 5, Sr has been deleted from the options for M^1 in the oxide represented by the formula $Ca_aA^1_bCo_cA^2_dO_e$ to be mixed in an electrically conductive paste for connecting a p-type thermoelectric material. This amendment is intended to clarify the difference from the oxide described in Funahashi et al. '381 (JP 2003-306381).

First, as is clear from amended Claim 4, the electrically conductive paste of Claim 4 of the present application is used to connect a p-type thermoelectric material made of a complex oxide to an electrically conductive substrate. When connecting such a p-type thermoelectric material made of a complex oxide to an electrically conductive substrate, noble metal pastes are not suitably used because there is a large difference in the thermal expansion coefficient between the oxide and the noble metal contained in the paste. Thus, repeated high-temperature power generations cause separation at the connecting portion, resulting in increased internal resistance of the modules and lowered mechanical strength. The connecting portion therebetween also has a problem of a large interface resistance due to contact between the metal and oxide. These problems are described in the specification of the present application on page 2, line 25 to page 3, line 5. When a substrate made of an oxide is used as an electrically conductive substrate, the

connecting portion between the substrate and the electrically conductive paste also has the same problem.

As a result of mixing a specific complex oxide powder and a specific metal powder in the electrically conductive paste of Claim 4, the present invention make it possible to solve the above-described problems that occur when connecting a p-type thermoelectric material made of a complex oxide to an electrically conductive substrate. This is evident in reference to, for example, Fig. 5 of the present specification. Fig. 5 is a chart showing the relationship between the internal resistance and the temperature of the substrate of each thermoelectric element of Example 1 and a Comparative Example in which a silver paste was used to connect a thermoelectric material. In the chart, over the entire temperature range (373 K-1,073 K) for measurement, the internal resistance of the element of Example 1 is lower than that of the element of the Comparative Example. The results also suggest that in the element of Example 1, the separation of the thermoelectric material was prevented and the resistance was kept low, even when the element was heated to a high temperature; and that since the internal resistance was low in the relatively low temperature range, the interface resistance of the connecting portion between the electrically conductive paste and the thermoelectric material was reduced by mixing a specific oxide powder in the electrically conductive paste.

Therefore, it is obvious that the use of the electrically conductive paste of Claim 4 of the present application to connect a p-type thermoelectric material made of a complex oxide to an electrically conductive substrate has remarkable effects in that the separation at the connecting portion is prevented even when high-temperature power generations are repeated, and the

interface resistance of the connecting portion between the electrically conductive paste and the thermoelectric material is reduced.

On the other hand, Xu et al. teaches that a material represented by $\text{Ca}_{3-x}\text{Na}_x\text{Co}_4\text{O}_9$ has thermoelectric conversion performance. As already mentioned, Claim 4 has been amended to delete Na from the options for A^1 in $\text{Ca}_a\text{A}^1_b\text{Co}_c\text{A}^2_d\text{O}_e$. This amendment excludes the complex oxide described in Xu et al. from the complex oxides to be mixed in the paste of Claim 4 of the present application. Accordingly, Xu et al. no longer discloses the complex oxides to be mixed in the paste of Claim 4 of the present application.

Moreover, although Xu et al. refers to the performance of the material represented by $\text{Ca}_{3-x}\text{Na}_x\text{Co}_4\text{O}_9$ as a thermoelectric material, it is silent about a paste for connecting a thermoelectric material to an electrically conductive substrate.

In this regard, the Examiner alleged that Xu et al. teaches the use of a metal paste on page 74, left column. However, the referred portion simply indicates that Pt paste was used for the terminal connections when the resistivity was determined using a DC standard four-probe method. As is widely known, a DC standard four-probe method can disregard the contact resistance, wiring resistance, etc. in the resistivity measurement. Naturally, no means is necessary to reduce the interface resistance of the connecting portion between the terminal and the thermoelectric material; the only necessity is a sufficiently strong connection between the terminal and the thermoelectric material. Xu et al. merely shows an example using a widely known noble metal paste as a paste for use in such an application.

Therefore, when connecting a p-type thermoelectric material made of a complex oxide to an electrically conductive substrate, a means for preventing the separation of the thermoelectric material and a means for reducing the interface resistance between the electrically conductive paste and the thermoelectric material cannot be discerned from the teachings of Xu et al.

The paste described in Alexander is a via fill paste for use in the construction of electronic circuit devices, and has nothing to do with thermoelectric materials. Even if the paste of Alexander is a conductive paste, it is used to connect conductive layers made of dissimilar metals (refer to column 1, lines 58-60 of Alexander). The target for connection in Alexander is different from that of the present invention, in which a p-type thermoelectric material made of a complex oxide is connected to an electrically conductive substrate. When connecting dissimilar metals, which are the target for connection in Alexander, the Kirkendahl effect due to different diffusion rates of metal elements generates holes. Particularly, in the connection of a gold layer and a silver layer, which is a problem of Alexander, the markedly different diffusion rates of gold and silver in each other can produce a buildup of Kirkendahl voids, resulting in an open circuit. As a paste that can solve the problem of the formation of Kirkendahl voids when connecting dissimilar metals, Alexander discloses a paste comprising gold, silver, palladium and a refractory oxide (refer to column 1, lines 43-66 of Alexander).

In contrast, as is clear from amended Claim 4, the electrically conductive paste of the present invention is used to connect a p-type thermoelectric material made of a complex oxide to an electrically conductive substrate. Thus, since the paste of the present invention is not used to connect dissimilar metals as in Alexander, the targets for connection of the present invention

naturally does not form Kirkendahl voids, which is the problem of Alexander. Therefore, the means for solving the problem that occurs when connecting dissimilar metals in Alexander is not helpful in the present invention.

As described above, Xu et al. merely describes the use of Pt paste for the terminal connections when the resistivity of the oxide represented by $\text{Ca}_{3-x}\text{Na}_x\text{Co}_4\text{O}_9$ is measured. Hence, regarding an electrically conductive paste for connecting a p-type thermoelectric material made of a complex oxide to an electrically conductive substrate, Xu et al. teaches nothing about a means for preventing the separation of the thermoelectric material and a means for reducing the interface resistance between the electrically conductive paste and the thermoelectric material. In addition, Xu et al. makes no reference to the complex oxide to be mixed in the electrically conductive paste of amended Claim 4.

Moreover, Alexander only discloses a paste that can prevent the formation of Kirkendahl voids when connecting dissimilar metals; the target for connection and the problem to be solved in Alexander are completely different from those of the present invention. Alexander merely describes an oxide-containing paste having a specific composition as a paste for connecting targets that are different from those of the present invention.

Accordingly, there is no motivation to combine Xu et al. with Alexander. Even if both were combined, it would not have been predicted that the specific problem that occurs when connecting a p-type thermoelectric material made of a complex oxide to an electrically conductive substrate can be solved by using the electrically conductive paste comprising a specific complex oxide powder and a specific metal powder.

For at least these reasons, claims 4-7 patentably distinguish over Xu et al. and Alexander.

Claims 4-7 were rejected under 35 U.S.C. 103(a) as being obvious over Funahashi et al. '381 (JP 2003-306381), in view of Alexander .

Claim 4 has been amended to exclude Sr from the options for M^1 in the oxide represented by $Bi_iPb_gM^1_hCo_jM^2_kO_k$. This amendment differentiates the complex oxide to be mixed in the electrically conductive paste of Claim 4 of the present application from the complex oxide of Funahashi et al. '381.

Funahashi et al. '381 discloses a method of producing an oxide represented by $Bi_{1.6-2.2}Pb_{0-0.5}Sr_{1.6-2.2}Co_2O_{8.6-9.4}$. However, it is silent about a paste for connecting a thermoelectric material to an electrically conductive substrate.

It is not expected from Funahashi et al. '381 that the above-described problems that occur when connecting a p-type thermoelectric material made of a complex oxide to an electrically conductive substrate can be solved by using the electrically conductive paste comprising a specific complex oxide powder and a specific metal powder recited in Claim 4 of the present application.

Moreover, as discussed in above, Alexander simply discloses a paste that can prevent the formation of Kirkendall voids when connecting dissimilar metals; the target for connection and the problem to be solved in Alexander are completely different from those of the present invention.

In light of the above, there is no reason to combine Funahashi et al. '381 and Alexander. Even if both were combined, it would not have readily been expected that the electrically conductive paste comprising a specific complex oxide powder and a specific metal powder can resolve the specific problem that occurs when connecting a p-type thermoelectric material made of a complex oxide to an electrically conductive substrate, which is completely different from the connection described in Alexander.

Consequently, Claim 4 and 5-7 dependent thereon of the present application are not obvious from Alexander and Funahashi et al. '381.

Claims 13, 14, 17 and 18 have been cancelled. Accordingly, the reasons for rejection of these claims will be resolved.

Claims 13 and 14 were rejected under 35 U.S.C. 103(a) as being obvious over Xu et al. or Funahashi et al. '381 and Yoshimoto et al. (U.S. Patent No. 5,352,299) or Funahashi et al. '686 (WO 03/081686), in view of Alexander.

Claims 13-14 are herein cancelled. Thus, this rejection is now moot.

Claims 17 and 18 were rejected under 35 U.S.C. 103(a) as being obvious over Xu et al. or Funahashi et al. '381 and Yoshimoto et al. (U.S. Patent No. 5,352,299) or Funahashi et al. '686 (WO 03/081686), in view of Alexander, as applied to claim 13 above, and further in view of Buist (U.S. Patent No. 4,859,250).

Claims 17 and 18 are herein cancelled. Thus, this rejection is now moot.

Double Patent Rejection

Claims 4-7, 13, 14, 17 and 18 were provisionally rejected on the ground of nonstatutory obviousness-type double patenting as being obvious over claims 1-9 of copending Application No. 10/593,644 in view of Funahashi et al.

Applicant submits herewith a Terminal Disclaimer to Obviate a Provisional double Patenting Rejection over a Pending “Reference” Application. Thus, this rejection should be withdrawn.

In view of the aforementioned amendments and accompanying remarks, Applicant submits that the claims, as herein amended, are in condition for allowance. Applicant requests such action at an early date.

If the Examiner believes that this application is not now in condition for allowance, the Examiner is requested to contact Applicant’s undersigned attorney to arrange for an interview to expedite the disposition of this case.

Application No. 10/574,844
Art Unit: 1795

Amendment under 37 C.F.R. §1.111
Attorney Docket No. 062327

If this paper is not timely filed, Applicant respectfully petitions for an appropriate extension of time. The fees for such an extension or any other fees that may be due with respect to this paper may be charged to Deposit Account No. 50-2866.

Respectfully submitted,
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Enclosures: Verified English translation of Japanese Patent Application No. 2003-348913; and
A Terminal Disclaimer to Obviate a Provisional double Patenting Rejection over a
Pending "Reference" Application